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# Chemical Study of Meats

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# A CHEMICAL STUDY OF MEATS,

## THEIR DIGESTIBILITY, AND THE LOSSES AND CHANGES INVOLVED IN COOKING

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Thesis
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MASTER OF SCIENCE in Chemistry

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June 4th, 1900

THIS IS TO CERTIFY THAT THE THESIS PREPARED UNDER MY SUPERVISION BY

Horace C. Porter

ENTITLED A Chemical Study of Meats, their digestibility, and losses & changes involved in Cooking.

IS APPROVED BY ME AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE DEGREE

OF Master of Science in Chemistry.

Arthur W. Palmer

HEAD OF DEPARTMENT OF Chemistry.

## INTRODUCTION.

The investigations herein reported consist mainly of a study of meats, inrespect to methods of cooking, the losses incurred by different methods and the comparative effect on digestibility of different methods of cooking. In connection with the determination of the losses in boiling meat, a study of the methods for the analysis of meat broths was made.

## METHODS FOR ANALYSIS OF BROTHS.

### Previous Work on Subject.

Some work on the improvement of methods for the analysis of meat and meat broths had been done in this laboratory during the preceding year. (1.) It was found then by careful experiment that no loss of nutrient material occurred by volatilization in boiling meat. All nutrients removed by boiling pass into the liquor or broth. It is evidently then only necessary in order to determine the losses in boiling meat, to analyze accurately the cooked meat and the soup. By summation of the constituents of these, the constituents of the original raw meat are computed, and thence the percentage loss of each. It is plain therefore that the accuracy of the experiments determining the losses in the boiling of meat, and the reliability of the results obtained rest almost entirely upon the accuracy and thoroughness of the analysis of the broths.

It should be noted however in this connection that the sum of the constituents of cooked meat and broth does not represent, strictly speaking, the original composition of the fresh raw meat. There have doubtless been changes involved in the process of cook-

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ing affecting the constitution of the nitrogenous bodies in the meat, such as for example, the formation of creatin, amids, compounds, etc. from albumin. These simpler decomposition products constitute a large percentage of the nitrogenous matter in the soup, and but a very small part of that in the raw meat. There would be error in assuming that all the nitrogenous bodies in the broth are contained as such in the original sample of meat. Until further investigations are made however on the nature of these changes in nitrogenous matter by cooking, we cannot do better than regard the constituents of the broth as representing the loss on cooking.

We have been unable to find record of any investigations made in this country on the analysis of meat broths. In Germany considerable work has been done by Koenig, Stutzer, and others (2.3) on "meat extracts". These extracts, however, are prepared by extracting the juices of meat under pressure, and their composition and the methods used in their analysis are not comparable with that of soups prepared by cooking. In 1884, A. Vogel (4.) made analyses of broths resulting from the boiling of meat by different methods. He showed that more nutrients are abstracted from the meat by raising the temperature gradually from cold to boiling than by placing the meat immediately in boiling water and thus coagulating the albumen. He paid particular attention to the comparative amounts of total nitrogen in the two broths. In 1893, Fr. Nothwang (5.) made experiments to determine the losses involved in boiling and steaming fresh and salted meat. He determined in the broth the solid proteid material separated from the meat, and the salts and total nitrogen in the clear broth, comparing the losses in the fresh and corned meat.

In 1897, the French Chemist, A. Gautier (6.) made analyses of meat, meat juices, meat ash, and meat broths, during the course of an investigation of fresh and refrigerated beef. His work on broths was more complete than any other of which record has been found. He separated the different forms of nitrogen and the reducing materials in the broth. This work will be again referred to below.

Previously to the work described in this thesis, it had been attempted in this laboratory to analyze the broths by evaporating to dryness and sampling for analysis the solids thus obtained. (7.) The mechanical difficulties of sampling prevented good results by this method. It was hence rejected and recourse was had to methods of sampling and analyzing the liquid broth itself. The chief difficulties to be overcome in this method seemed to be the following:

1. to filter the broth clear in a reasonably short time, thus making it possible to sample it accurately, and to collect by this filtration all fat and suspended solid matter in a condition fit for drying, weighing, and analyzing.

2. to determine accurately the total solids in the clear broth avoiding decomposition of nitrogenous matter.

3. to determine the distribution, or forms of combination of the nitrogen in the clear broth.

## Methods for Filtration.

In the cooking experiments which we describe below, it is considered that all material separated from the meat, either mechanically, or by solution is included in the loss by cooking. Therefore in the analysis of the broth, it is necessary to filter

out and analyze all suspended solid matter, coarse and fine, as well as to analyze the resulting clear filtrate.

By various attempts to filter the entire amount of broth, trying in turn a Buechner porcelain funnel, a Gooch crucible with paper, the same with asbestos, and an ordinary glass funnel with hardened paper filter, it was found impracticable to obtain a clear filtration of the entire amount in a reasonably short time. In all methods the pores of the filter appeared to become clogged by the suspended particles of fat and gelatinous material rendering the filtration so slow, that before it could be completed, a separation of solid matter, due to decomposition took place in the filtrate. It being therefore impracticable to filter the entire amount the only alternative seemed to be the filtration of an aliquot portion sufficient for analysis. This method was adopted and found to be quite satisfactory.

By rapid cooling of the broth to 15° C. immediately after cooking, and straining through a counterpoised piece of cheesecloth, the coarser particles of solid matter and most of the fat, — solid at this temperature, — can be removed, dried, weighed, and analyzed. The strained broth, — now of a fairly homogenous character, is made up to a definite volume ( usually 2000 c. c.) and well mixed. Aliquot portions of 200 c. c. each are taken in duplicate for filtration and analysis. This second filtration is done through hardened papers, 11 c. m. in diameter, using suction. The papers having been previously counterpoised, the residues can be dried and weighed. The broth filters clear in this way, and 200 c. c. when warmed slightly, may be filtered in 30 minutes.

Analysis of Residues from Filtration.

The coarse residue on cheesecloth is dried at 100° C. over a weighed glass flask to catch the fat drippings, and complete extraction of the fat is then accomplished in the Soxhlet apparatus. After extraction the residue is weighed, the nitrogen determined by the Kjehldahl method, and the ash by difference.

The fine residue on paper is dried at 100° C., weighed, extracted for fat in Soxhlet tube and Kjehldahled for nitrogen. By blank determinations, it was found that no nitrogen was contained either in the cheese-cloth or the filter paper used. Nitrogen in these residues was considered as being entirely in the form of protein ( nitrogen multiplied by 6.25 ).

Determination of Solids.

To determine solids in the clear broth we have experimented with several methods in the endeavor to find one causing no decomposition of the nitrogenous constituents. By the simple method of evaporating on the water bath and drying at 100° C. to constant weight, there was found to be no loss of nitrogen and no change in the amount of albuminoids precipitated by bromine. This fact was determined by obtaining the solids at the temperature named, in a Kjehldahl digestion flask, taking up again with hot water and determining total and albuminoid nitrogen as described below.

To check the results obtained by this ordinary method of drying, however, two other methods were used. Ignited pumice stone in pieces the size of a pea was placed in shallow aluminum dishes, moistened with 5 c. c. of water and dried exactly as described below for the broth.

The dishes were weighed and 5 c. c. of the broth distributed evenly over the pumice. This was partially dried at 70° - 80° C., 5 c. c. more broth added and this in turn partially dried at 70° - 80°. The drying was then continued for eight hours at 75° C. in a slow current of dry air in a vacuum of 25 inches of mercury.

The other method tried was as follows. 25 c. c. of broth was distributed over a strip of filter paper about 7 c. m. by 60 c. m. in size, which had been previously dried and weighed . These strips containing the broth were rolled up and dried in a vacuum as described above for the pumice stone method. The weighings were made in telescopic tubes to avoid the absorption of hygroscopic moisture.

A comparison of results by the three methods on all the broths analyzed is shown in the table:

| | Solids in 50 c. c. | | |
|---|---|---|---|
| Lab. No. | Ordinary Method at 100° | Pumice Method in Vacuum at 75° C. | Paper coil Method in Vacuum at 75° C. |
| 774 a | .4023 | .4473 | .3750 |
| 774 b | .4328 | .4450 | .3918 |
| 778 a | .5021 | .5735 | .4538 |
| 778 b | .4870 | .5505 | .4530 |
| 780 a | .5098 | .5265 | .4480 |
| 780b | .4807 | .4905 | .4720 |
| 782 a | .4109 | .4265 | .4612 |
| 782 b | .4931 | .5145 | .4986 |
| 819 a | .4604 | .4600 | ,4600 |
| 819 b | .4564 | .4510 | .4678 |
| 821 a | .3016 | ----- | ----- |
| 821 b | ,3802 | ----- | ----- |
| 824 a | .3904 | .3935 | ----- |
| 824 b | .4498 | .4520 | ----- |
| 772 a | .3466 | ----- | ----- |
| 772 b | .3308 | ----- | ----- |

It will be seen that the results by the pumice method are uniformly high, while those by the paper coil method are low. The latter method is unsatisfactory since it is almost impossible to avoid loss of small bits of paper fiber in handling. The ordinary method gives lower results than the pumice and therefore probably accomplishes a more thorough drying. Since, as proven above, this method causes no loss of nitrogen, it was concluded to be the most satisfactory of the three.

## Analysis of Clear Broth; Determination of Salts, and Ether Extract.

In the filtered broth were determined ether extract, nitrogenous matter, and salts. To determine the salts, the solids were ignited to a red heat in platinum. The ether extract was obtained in a Soxhlet apparatus by extracting eight hours with anhydrous ether the solids from 25 c. c. distributed over a strip of absorbent paper, and dried thoroughly. A Kjehldahl determination on this extract showed no nitrogen present.

## Distribution of Nitrogen.

The distribution of nitrogen in meat broth as well as in meat juices and extracts seems to be an unsettled question.

Salkowski and Giese (8.) found by experiments in 1897 that " 12% of the nitrogen in meat is in extractive matter not coagulated by heat. This includes not only the flesh bases, but also substances allied to protein such as albumoses, peptones, amd the newly-discovered sarco-phosphoric acid."

A. Gautier's work on meat broths (6) to which reference has been made above, showed the nitrogen to be distributed in the broth as follows:

Peptones and propeptones, - 28.8 % of solids.

Gelatinoids, - 14.1 % " "

Creatin and other bases, - 10.9 % " "

He found about 8 % of the solids to consist of inosite, glycogen, and other reducing material, about 14 % extractives, and 24 % salts, the remainder ( 53.8 % ) being nitrogenous matter distributed as given above.

We have attempted to separate albuminoids from flesh bases by the Bromine method of Wiley (9). The bromine was added in considerable excess to the acidulated broth ( with hydrochloric acid), the mixture well shaken and allowed to stand over night before filtering out the precipitated albuminoids. The difference between the nitrogen in this precipitate and the total nitrogen in the same volume of broth was regarded as being in flesh bases entirely and the factor 3.12 used. For the precipitated albuminoids the factor 6.25 was used. The amount of proteid thus obtained was quite small in relation to the amount of flesh bases. Compared with those of Gautier, our results are as follows:

Nitrogenous constituents of Broth, calculated to percentages of total solids.

| | Representative samples of our analyses | | | | Gautier's |
|---|---|---|---|---|---|
| | 778 a | 778 b | 780 a | 782 a | Analyses. |
| Albuminoids | 12.9 | 13.1 | 14.7 | 12.8 | 42.9 % |
| Flesh Bases | 27.3 | 28.7 | 27.2 | 25.2 | 10.9 % |
| Total | 40.2 | 41.8 | 41.9 | 38.0 | 53.8 % |

Gautier's broth may or may not have been filtered from the suspended, coagulated protein. This however would affect only slightly the figures given above, increasing by perhaps 2 % our figures for albuminoids, as a calculation from the amount of residues shows.

Koenig and Boemer (10) in an investigation of meat extracts, found in Liebig's Extract of Beef the nitrogen distributed as follows:

| | |
|---|---|
| Albumoses and allied compounds, | - 12.6 % |
| Flesh Bases, | - 73.4 % |
| Ammonia | - 5.1 % |
| Other forms | - 8.9 % |

Although our results on the distribution of nitrogen between albuminoid material and flesh bases differ materially from those of Gautier, on the other hand Koenig and Boemer's finding of 73 % of the nitrogenous matter in meat extract as flesh bases agrees more nearly with our average of 75 % for the same in broth. Gautier states that his broth was prepared by boiling 1 kilo. of beef a long time in 2500 c. c. of water. We have found it true ( see Cooking Experiment Number 24) that a long-continued boiling separates an excess of solid, coagulated albumen from the meat. His

high per cent of albuminoids may therefore be explained by the large amount of coagulated matter formed by long boiling. The state of division of the meat would also affect this separation of coagulated matter. Our broths were obtained in nearly every case by boiling one large piece of meat ( about 1 Kilo.) for 2 hours in 2000 c. c. of water.

Allen and Searle (11.) claim that bromine precipitates all albumen, peptones, and intermediate products such as albumoses, and Wiley holds that his Bromine Method is well adapted to meat extracts, soups, and other meat products.

Summation of Constituents.

By summation of the salts, ether extract, and nitrogenous matter, we have in our analyses accounted for about 75 % of the total solids in the clear broth. Some of our analyses, compared with that of Gautier are shown in the table.

| | Representative Samples of our Analyses | | | | Gautier's |
|---|---|---|---|---|---|
| | 778 a | 778 b | 780 a | 782 a | Analyses |
| Peptones and Propeptones | 12.9 * | 13.1 | 14.7 | 12.8 | 28.8 |
| Gelatinoids | | | | | 14.1 |
| Creatin and Other Bases | 27.3 | 28.7 | 27.2 | 25.2 | 10.9 |
| Inosite, Glycogen and other Reducing Material. | — — | — — | — — | — — | 8.0 |
| Extractives (by ether) | 13.6 | 15.6 | 13.9 | 1.9 | 14.0 |
| Mineral Salts | 24.6 | 22.9 | 24.0 | 23.2 | 24.2 |
| Total | 78.4 | 80.3 | 79.8 | 63.1 | 100.0 |

The remaining constituents necessaryto bring the totals in our analyses to 100 % may consist of reducing materials such as inosite and glycogen. The difference is much more probably, to be explained in large part by error in the factors used for calculation of nitrogenous bodies.

Our separation of the forms of nitrogen has been unsatisfactory at best, and further study of the subject is necessary.

*Percentage of each Constituent in Total Solids.

## COOKING EXPERIMENTS WITH MEAT.

### Previous Work on Subject.

Previous investigations in this laboratory on the losses involved in the cooking of meats, (12.) have shown that on cooking a piece of beef round weighing about two pounds, by placing in boiling water for 10 minutes, then cooling to 80° C., and maintaining this temperature for two hours, the beef loses one sixteenth of its nitrogenous matter, one eighth of its fat, and one half of the mineral salts. It was shown that these materials pass entirely into the broth, none being lost by volatilization. One or two experiments were also made to determine whether any greater or less loss occurs if the meat be placed first in cold water and this then gradually raised to the boiling point. The results of these latter experiments seemed to indicate that the losses by the two methods of boiling were practically the same.

At that time the methods for sampling and analyzing the broths were unsatisfactory and incomplete, and the results of the boiling experiments were not considered fully reliable. The experiments reported in this thesis were undertaken with a view to corroborating the results of the previous year by a more extended series of experiments, and by the use of the more complete and satisfactory methods for broth analysis which have been described above.

We have found no record of any cooking experiments made in this country on meat. H. Snyder of the Minnesota Agricultural Experiment Station (13.) and E. B. Voorhees of the New Jersey Station (14.), have investigated the losses incurred in the cooking of vegetables. A. Goss of the New Mexico Station (15.) and Chas. E. Wait

of the Tennesee Station 16. have studied carefully the methods for the analysis of meat.

The work of the German chemist, Nothwang, has been referred to above (5). He made cooking experiments to compare the losses on boiling and steaming fresh and salted meats, analyzing, for total nitrogen, salts, and extractive matters, the broths thus obtained. We have also referred to the work of Gautier at Paris on the comparative analyses of fresh and refrigerated beef. He boiled a kilogram of beef a long time in 2500 c. c. of water and analyzed the resulting broth. He found in one liter, 18.4 grams of solids, made up of peptones and propeptones 5.3 grams, gelatinoids 2.6 grams, creatin and other bases 2.0 grams, inosite and glycogen 1.4 grams, extractives 2.6 grams and salts 4.5 grams.

In the present investigation we have performed eight experiments on the cooking of beef by first placing in boiling water and then cooking at 80° C. for two hours; four experiments by bringing gradually from cold to boiling, then reducing to 80° C. and cooking thus two hours; and two experiments by bringing gradually from cold to 50° C., and cooking thus for five hours.

Methods of Cooking.

Experiments Number 20, 21, 22, and 23, each of which was run in duplicate were conducted as follows: A piece of the first cut of beef round, weighing from six to eight pounds, about 3 inches thick, and freshly cut from a whole side, was trimmed carefully of bone and grissle, and most of the visible fat removed. Two pieces, each weighing from 0.7 to 1.0 kilo., and as like as possible in texture and fat content, were cut from this large piece and weighed quickly for the experiment. Each was plunged into 1500

c. c. of rapidly boiling distilled water and boiled vigorously for 10 minutes. Cold water was then added until temperature was reduced to 80°, which temperature was maintained two hours. The meat was removed, suspended over the kettle to drain for 10 minutes, weighed, passed through the sausage mill three times, well mixed, and sampled for air-drying and analysis. The broth was cooled to 15°, filtered and analyzed.

In Experiments No. 17 and 25, the meat was prepared for cooking as above described, placed in cold water (at 20° C.), and the temperature gradually raised during 45 minutes to the boiling point. The boiling was continued 10 minutes and cold water then added to reduce the temperature to 80°. This temperature was maintained two hours, and the cooked meat and broth analyzed as before.

In Experiment No. 24, the meat was prepared as before, placed in cold water, and the temperature gradually raised during 30 minutes to 50° C. This temperature was maintained for 5 hours, 30 minutes, and the meat and broth analyzed as usual.

Cooking Experiment Number 17.

Table No.1.

Total Loss in Weight by Cooking.

| Lab. No. | Weight of Sample taken for Cooking | Weight of meat after Cooking | Loss in Wt. by process of Cooking | Percentage Loss in Cooking |
|---|---|---|---|---|
| 771 a | 705.50 | 415.90 | 289.60 | 41.05 |
| 771 b | 660.75 | 388.00 | 272.75 | 41.29 |

Table No.2.

Amount and Composition of Suspended Matter in Broths.

| Lab. No. | Weight of Sample taken for Cooking | Combined Weight of residues from filtration of broths | Weight of Protein in total residues | Weight of Fat in Total Residues. |
|---|---|---|---|---|
| 771 a | 705.5 | 7.474 | 1.757 | 5.144 |
| 771 b | 660.8 | 9.608 | 1.936 | 7.242 |

Table No.3.

Composition of Clear Filtered Broth.

| Broth from Lab. No. | Volume of broth (c.c.) | Total weight of each constituent of filtered broth. Total Solids by Direct Determination | Protein (Nx6.25) | Flesh Bases (Nx3.12) | Total Nitrog. Matter | Fat | Ash | Total by Summation |
|---|---|---|---|---|---|---|---|---|
| 771a | 2500 | 17.330 | 0.370 | 5.505 | 5.875 | 0.840 | 4.044 | 10.759 |
| 771b | " | 16.540 | 0.605 | 5.010 | 5.615 | 0.890 | 3.875 | 10.380 |

Cooking Experiment Number 17 (continued)

Table No.4.

Composition of Original Broth (Complete)

| Broth from Lab. No. | Wt. of Sample taken for cooking | Volume of Broth (c.c.) | Total weight of Nutrients in Original Broth. Protein (Nx6.25) | Flesh Bases (Nx3.12) | Total Nitrog. Matter | Fat | Ash |
|---|---|---|---|---|---|---|---|
| 771a | 705.5 | 2500 | 2.127 | 5.505 | 7.632 | 5.984 | 4.044 |
| 771b | 660.8 | 2500 | 2.541 | 5.010 | 7.551 | 8.132 | 3.875 |

Table No.5.

Preparation and Analysis of Air-dried Material in Cooked Meat.

| Lab. No. | Preparation of Air-dried Material: Wt. of Sample taken for Air-drying | water removed: Wt. in grams | water removed: per cent | Analysis of Air-dried Material: Water | Protein | Fat | Ash | Total |
|---|---|---|---|---|---|---|---|---|
| 771a | 58.55 | 35.49 | 60.6 | 6.47 | 72.06 | 18.35 | 1.89 | 98.77 |
| 771b | 64.15 | 34.07 | 53.1 | 6.17 | 74.31 | 18.13 | 1.81 | 100.42 |

Table No.6.

Calculated Composition of Cooked Meat,- Fresh and Water free.

| Lab. No. | Composition of Fresh substance of cooked meat: Water | Protein | Fat | Ash | Total | Composition of Water free substance in cooked meat: Protein | Fat | Ash | Total |
|---|---|---|---|---|---|---|---|---|---|
| 771a | 63.17 | 28.38 | 7.23 | 0.74 | 99.52 | 77.06 | 19.63 | 2.01 | 98.70 |
| 771b | 56.01 | 34.84 | 8.50 | 0.85 | 100.20 | 79.20 | 19.32 | 1.93 | 100.45 |

Cooking Experiment Number 17. (continued)

Table No.7.

Percentage Loss of Each Constituent.

by Cooking.

| Lab. No 771 a | Total Weight of Nutrients in Cooked Meat | Broth | Raw meat (calculated) | Percentage Loss of Each Nutrient | % Loss of each calculated to fresh raw samp. |
|---|---|---|---|---|---|
| Nitrog. Matter | 118.11 | 7.632 | 125.74 | 6.07 | 1.08 |
| Fat | 30.07 | 5.984 | 36.05 | 16.60 | 0.85 |
| Ash | 3.08 | 4.044 | 7.12 | 56.79 | 0.57 |
| Total | | 17.660 | | | 2.50 |

Total Loss by direct weighing,- 41.1 %

Total Loss of Nutrients,- 2.50 %

Loss of Water (by difference),- 38.5 %

| Lab. No. 771 b | | | | | |
|---|---|---|---|---|---|
| Nitrog. Matter | 135.18 | 7.551 | 142.73 | 5.22 | 1.14 |
| Fat | 32.98 | 8.132 | 41.11 | 19.79 | 1.23 |
| Ash | 3.30 | 3.875 | 7.18 | 53.97 | 0.59 |
| Total | | 19.558 | | | 2.96 |

Total Loss by direct weighing,- 41.29 %

Total Loss of Nutrients,- 2.96 %

Loss of Water (by difference),- 38.3 %

Method: Starting cold, bringing gradually to boil, cooking two hours at 80° C.

Remarks: Meat well done; broth thick and hard to filter; sample B more fat then A.

Cooking Experiment Number 20.

Table No.1.

Total Loss in Weight by Cooking.

| Lab. No. | Weight of Sample taken for Cooking | Weight of Meat after Cooking | Loss in weight by process of cooking | Percentage Loss in Cooking |
|---|---|---|---|---|
| 777a | 825.8 | 477.3 | 348.5 | 42.2 |
| 777b | 739.5 | 422.5 | 317.0 | 42.8 |

Table No.2.

Amount and Composition of Suspended Matter in Broth.

| Lab. No. | Weight of Sample Taken for Cooking | Combined Weight of residues from filtration of broth | Weight of Protein in total residues | Weight of Fat in total residues |
|---|---|---|---|---|
| 777a | 825.8 | 7.315 | 0.509 | 6.810 |
| 777b | 739.5 | 7.106 | 0.387 | 6.722 |

Table No.3.

Composition of Clear Filtered Broth.

| Broth from Lab. No. | Volume of Broth (c.c.) | Total Weight of each constituent of clear broth. Total Solids by Direct Determination | Protein (Nx6.25) | Flesh Bases (Nx3.12) | Total Nitrog. Matter | Ash | Fat | Total by Summation |
|---|---|---|---|---|---|---|---|---|
| 777a | 2000 | 20.3880 | 2.628 | 5.568 | 8.196 | 2.776 | 5.016 | 15.988 |
| 777b | " | 19.8720 | 2.604 | 5.624 | 8.228 | 3.104 | 4.576 | 15.908 |

Cooking Experiment Number 20 (continued)

Table No.4.

Composition of Original Broth (Complete)

| Broth from Lab. No. | Wt. of Sample taken for Cooking | Volume of Broth (c.c.) | Total Weight of Nutrients in Original Broth | | | | |
|---|---|---|---|---|---|---|---|
| | | | Protein (Nx6.25) | Flesh Bases (Nx3.12) | Total Nitrog. Matter | Fat | Ash |
| 777a | 825.8 | 2000 | 3.137 | 5.568 | 8.705 | 9.586 | 5.016 |
| 777b | 739.5 | " | 2.991 | 5.624 | 8.615 | 9.826 | 4.576 |

Table No.5

Preparation and Analysis of Air-dried Material in Cooked Meat.

| Lab. No. | Preparation of Air-dried Material | | | Analysis of Air-dried Material | | | | |
|---|---|---|---|---|---|---|---|---|
| | wt. of Sample taken for Air-drying | Water removed wt. in grs. | Water removed per cent | Water | Protein | Fat | Ash | Total |
| 777a | 77.26 | 40.73 | 52.7 | 6.04 | 70.06 | 22.34 | 1.87 | 100.31 |
| 777b | 81.58 | 41.20 | 50.5 | 5.72 | 69.69 | 23.26 | 1.83 | 100.50 |

Table No.6.

Calculated Composition of Cooked Meat, - Fresh and Water-free.

| Lab. No. | Composition of Fresh Substance of Cooked Meat | | | | | Composition of Water-free substance in cooked meat | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Water | Protein | Fat | Ash | Total | Protein | Fat | Ash | Total |
| 777a | 55.56 | 33.14 | 10.52 | 0.88 | 100.10 | 74.57 | 23.67 | 1.98 | 100.22 |
| 777b | 53.33 | 34.50 | 11.51 | 0.91 | 100.25 | 73.92 | 24.66 | 1.95 | 100.53 |

Cooking Experiment Number 20 (continued)

Table No.7.

Percentage Loss of Each Constituent by Cooking.

| Lab. No. 777 a | Total Weight of Nutrients in Cooked Meat | Broth | Raw Meat (calculated) | Percentage Loss of Each Nutrient | % Loss of each computed to fresh, raw, sample |
|---|---|---|---|---|---|
| Nitrog. Matter | 158.16 | 8.705 | 166.87 | 5.22 | 1.05 |
| Fat | 50.22 | 9.586 | 59.81 | 16.03 | 1.16 |
| Ash | 4.20 | 5.016 | 9.22 | 54.43 | 0.61 |
| Total | | 23.307 | | | 2.82 |

Total Loss by Direct Weighing- 42.2 %

Total Loss of Nutrients- 2.82 %

Loss of Water (by difference)- 39.4 %

| Lab. No. 777 b | | | | | |
|---|---|---|---|---|---|
| Nitrog. Matter | 145.76 | 8.615 | 154.38 | 5.58 | 1.16 |
| Fat | 48.63 | 9.826 | 58.46 | 16.81 | 1.33 |
| Ash | 3.84 | 4.576 | 8.42 | 54.37 | 0.62 |
| Total | | 23.017 | | | 3.11 |

Total Loss by Direct Weighing- 42.8 %

Total Loss of Nutrients- 3.11 %

Loss of Water (by difference)- 39.7 %

Method: Starting at boil, cooking 2 hours at 80° C.

Remarks: Samples rather small and very well done.

Cooking Experiment Number 21.

Table No.1.

Total Loss in Weight by Cooking.

| Lab. No. | Wt. of Sample Taken for Cooking | Wt. of Meat after Cooking | Loss in Weight by process of cooking | Percentage Loss in Cooking |
|---|---|---|---|---|
| 779 a | 750.0 | 402.7 | 347.3 | 46.3 |
| 779 b | 660.5 | 351.1 | 309.4 | 46.8 |

Table No.2.

Amount and Composition of Suspended Matter in Broths.

| Lab. No. | Wt. of Sample taken for Cooking | Combined weight of residues from filtration of broths | Wt. of Protein in Total Residues | Wt. of Fat in Total Residues |
|---|---|---|---|---|
| 779 a | 750.0 | 8.609 | 0.441 | 8.147 |
| 779 b | 660.5 | 5.173 | 0.495 | 4.668 |

Table No.3.

Composition of Clear Filtered Broth.

| Broth from Lab. No. | Volume of Broth (c.c) | Total weight of each Constituent of Filtered Broth: Total Solids by Direct Determination | Protein (Nx6.25) | Flesh Bases (Nx3.12) | Total Nitrog. Matter | Fat | Ash | Total by Summation |
|---|---|---|---|---|---|---|---|---|
| 779a | 2000 | 20.140 | 2.964 | 5.480 | 8.444 | 2.800 | 4.832 | 16.076 |
| 779b | 2000 | 19.344 | 2.824 | 5.256 | 8.080 | 1.772 | 4.432 | 14.284 |

Cooking Experiment Number 21 (continued)

Table No.4.

Composition of Original Broth (Complete)

| Broth from Lab. No. | Wt. of Sample taken for cooking | Volume of Broth (c.c.) | Total Weight of Nutrients in Original Broth | | | | |
|---|---|---|---|---|---|---|---|
| | | | Protein (Nx6.25) | Flesh Bases (Nx3.12) | Total Nitrog. Matter | Fat | Ash |
| 779a | 750.0 | 2000 | 3.405 | 5.480 | 8.885 | 10.947 | 4.832 |
| 779b | 660.5 | " | 3.319 | 5.256 | 8.575 | 6.440 | 4.432 |

Table No.5.

Preparation and Analysis of Air-dried Material in Cooked Meat.

| Lab. No. | Preparation of Air-dried material | | | Analysis of Air-dried Material | | | | |
|---|---|---|---|---|---|---|---|---|
| | Wt. of Sample taken for air-drying | water removed | | Water % | Protein % | Fat % | Ash % | Total % |
| | | Wt. in grams | per cent | | | | | |
| 779a | 66.03 | 33.21 | 50.3 | 5.34 | 75.02 | 18.06 | 1.62 | 100.04 |
| 779b | 64.44 | 33.14 | 51.4 | 5.69 | 79.44 | 12.07 | 1.73 | 98.93 |

Table No.6.

Calculated Composition of Cooked Meat - fresh and water free.

| Lab. No. | Composition of Fresh substance of cooked meat | | | | | Composition of Water-free substance in cooked meat | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Water | Protein | Fat | Ash | Total | Protein | Fat | Ash | Total |
| 779a | 52.95 | 37.28 | 8.98 | 0.81 | 100.02 | 79.23 | 19.09 | 1.72 | 100.04 |
| 779b | 54.17 | 38.61 | 5.87 | 0.84 | 99.49 | 84.25 | 12.81 | 1.83 | 98.89 |

Cooking Experiment Number 21 (continued)

Table No.7.

Percentage Loss of each constituent by cooking.

| Lab. No. 779a | Total weight of nutrients in cooked meat | Broth | Raw Meat (calculated) | Percentage Loss of each Nutrient | % Loss of each computed to fresh sample |
|---|---|---|---|---|---|
| Nitrog. Matter | 150.13 | 8.885 | 159.02 | 5.59 | 1.18 |
| Fat | 36.16 | 10.947 | 47.11 | 23.24 | 1.46 |
| Ash | 3.26 | 4.853 | 8.11 | 59.82 | 0.65 |
| Total | | 24.685 | | | 3.29 |

Total Loss by direct weighing,- 46.3 %

Total loss of nutrients,- 3.29 %

Loss of water (by difference)- 43.0 %

| Lab. No. 779 b | | | | | |
|---|---|---|---|---|---|
| Nitrog. Matter | 135.56 | 8.575 | 144.14 | 5.95 | 1.29 |
| Fat | 20.61 | 6.440 | 27.05 | 23.81 | 0.97 |
| Ash | 2.95 | 4.442 | 7.39 | 60.09 | 0.67 |
| Total | | 19.467 | | | 2.93 |

Total loss, by direct weighing,- 46.8 %

Total loss of nutrients,- 2.93 %

Loss of water (by difference)- 43.9 %

Method: Starting at boil, cooking 2 hours at 80° C.

Remarks: Samples small, and very well done; Sample A considerably more fat than B.

Cooking Experiment Number 22.

Table No.1.

Total Loss in Weight by Cooking.

| Lab. No. | Wt. of Sample taken for Cooking | Wt. of Meat after Cooking | Loss in Weight by Process of Cooking | Percentage Loss in Cooking |
|---|---|---|---|---|
| 781 a | 657.0 | 384.0 | 273.0 | 41.6 |
| 781 b | 755.8 | 424.9 | 330.9 | 43.8 |

Table No.2.

Amount and Composition of Suspended Matter in Broths.

| Lab. No. | Wt. of Sample Taken for Cooking | Combined weight of residues from filtration of broths | Wt. of Protein in Total Residues | Wt. of Fat in Total residues |
|---|---|---|---|---|
| 781 a | 657.0 | 6.260 | 0.422 | 5.734 |
| 781 b | 755.8 | 3.873 | 0.466 | 3.344 |

Table No.3.

Composition of Clear Filtered Broth.

| Broth from Lab. No. | Volume of Broth (c.c.) | Total Weight of Each Constituent of Filtered Broth: Total Solids by Direct Determination | Protein (Nx6.25) | Flesh Bases (Nx3.12) | Total Nitrog. Matter | Fat | Ash | Total by Summation |
|---|---|---|---|---|---|---|---|---|
| 781a | 2000 | 17.316 | 2.176 | 4.416 | 6.592 | 0.332 | 4.010 | 10.934 |
| 781b | " | 20.084 | 2.224 | 5.652 | 7.876 | 0.324 | 4.760 | 12.960 |

Cooking Experiment Number 22 (continued)

Table No.4.

Composition of Original Broth (Complete)

| Broth from Lab. No. | Wt. of Sample taken for cooking | Volume of Broth (c.c.) | Total Weight of Nutrients in Original Broth. Protein (Nx6.25) | Flesh Bases (Nx3.12) | Total Nitrog. Matter | Fat | Ash |
|---|---|---|---|---|---|---|---|
| 781a | 657.0 | 2000 | 2.598 | 4.416 | 7.014 | 6.066 | 4.010 |
| 781b | 755.8 | " | 2.690 | 5.652 | 8.342 | 3.668 | 4.760 |

Table No.5.

Preparation and Analysis of Air-dried Material in Cooked Meat.

| Lab. No. | Preparation of Air-dried material: Wt. of Sample taken for air-drying | water removed: Wt. in grains | per cent | Analysis of Air-dried Material: Water | Protein | Fat | Ash | Total |
|---|---|---|---|---|---|---|---|---|
| 781a | 57.08 | 29.24 | 51.2 | 4.92 | 70.13 | 21.13 | 1.93 | 98.11 |
| 781b | 59.64 | 31.90 | 53.5 | 5.62 | 77.19 | 13.98 | 1.87 | 98.66 |

Table No.6.

Calculated Composition of Cooked Meat Fresh and Water free.

| Lab. No. | Composition of Fresh substance of cooked meat: Water | Protein | Fat | Ash | Total | Composition of Water-free substance in cooked meat: Protein | Fat | Ash | Total |
|---|---|---|---|---|---|---|---|---|---|
| 781a | 53.60 | 34.22 | 10.31 | 0.94 | 99.07 | 73.76 | 22.22 | 2.03 | 98.01 |
| 781b | 56.11 | 35.89 | 6.50 | 0.87 | 99.37 | 81.78 | 14.81 | 1.98 | 98.57 |

Cooking Experiment Number 22 (continued)

Table No.7.

Percentage Loss of each Constituent in Cooking.

| Lab. No. 781 a | Total weight of nutrients in cooked meat | Broth | Raw Meat (calculated) | Percentage Loss of each Nutrient | % Loss of each computed to fresh sample |
|---|---|---|---|---|---|
| Nitrog. Matter | 131.41 | 7.014 | 138.42 | 5.07 | 1.07 |
| Fat | 39.59 | 6.066 | 45.66 | 13.39 | 0.92 |
| Ash | 3.61 | 4.010 | 7.62 | 53.81 | 0.61 |
| Total | | 17.090 | | | 2.60 |

Total loss, by direct weighing,- 41.55 %

Total loss of nutrients,- 2.60 %

Loss of water (by difference)- 38.95 %

| Lab. No. 781 b | | | | | |
|---|---|---|---|---|---|
| Nitrog. Matter | 153.40 | 8.342 | 161.74 | 5.16 | 1.10 |
| Fat | 27.62 | 3.668 | 31.29 | 11.72 | 0.49 |
| Ash | 3.70 | 4.760 | 8.46 | 56.26 | 0.63 |
| Total | | 16.770 | | | 2.22 |

Total Loss, by direct weighing,- 43.79 %

Total loss of nutrients,- 2.22 %

Loss of water (by difference)- 41.57 %

Method: Starting at boil, cooking two hours at 80°.

Remarks: Samples small and well done: Sample A considerably more fat than B.

Cooking Experiment Number 23.

Table No.1.

Total Loss in Weight by Cooking.

| Lab. No. | Wt. of Sample taken for Cooking | Wt. of Meat after Cooking | Loss in Weight by process of cooking | Percentage Loss in Cooking |
|---|---|---|---|---|
| 809 a | 742.8 | 408.1 | 334.7 | 45.1 |
| 809 b | 686.6 | 380.0 | 306.6 | 44.7 |

Table No.2.

Amount and Composition of Suspended Matter in Broths.

| Lab. No. | Wt. of Sample taken for Cooking | Combined Wt. of residues from filtration of broths | Wt. of Protein in Total Res. | Wt. of Fat in Total residues |
|---|---|---|---|---|
| 809 a | 742.8 | 8.512 | 0.334 | 8.134 |
| 809 b | 686.6 | 5.370 | 0.277 | 5.082 |

Table No.3.

Composition of Clear Filtered Broth.

| Broth from Lab. No. | Volume of Broth (c.c.) | Total Weight of Each Constituent of Filtered Broth. Total Solids by Direct Determination | Protein (Nx6.25) | Flesh Bases (Nx3.12) | Total Nitrog. Matter | Fat | Ash | Total by Summation |
|---|---|---|---|---|---|---|---|---|
| 809a | 2000 | 18.416 | 1.072 | 5.376 | 6.448 | 0.392 | 4.576 | 11.416 |
| 809b | 2000 | 18.336 | 0.812 | 5.452 | 6.264 | 0.260 | 4.460 | 10.984 |

Cooking Experiment Number 23 (continued)

Table No.4.

Composition of Original Broth (Complete)

| Broth from Lab. No. | Wt. of Sample taken for cooking | Volume of Broth (c.c.) | Total Weight of Nutrients in Original Broth. Protein (Nx6.25) | Flesh Bases (Nx3.12) | Total Nitrog. Matter | Fat | Ash |
|---|---|---|---|---|---|---|---|
| 809a | 742.8 | 2000 | 1.406 | 5.376 | 6.782 | 8.526 | 4.576 |
| 809b | 686.6 | " | 1.089 | 5.452 | 6.541 | 5.342 | 4.460 |

Table No.5.

Preparation and Analysis of Air-dried Material in Cooked Meat.

| | Preparation of Air-dried Material | | | Analysis of Air-dried Material | | | | |
|---|---|---|---|---|---|---|---|---|
| | | water removed | | | | | | |
| Lab. No. | Wt. of Sample taken for air-drying | Wt. in grams | per cent | Water | Protein | Fat | Ash | Total |
| 809a | 46.02 | 24.46 | 53.15 | 4.13 | 74.63 | 20.06 | 1.81 | 100.63 |
| 809b | 46.12 | 24.98 | 54.16 | 3.49 | 81.09 | 13.84 | 2.04 | 100.46 |

Table No.6.

Calculated Composition of Cooked Meat Fresh and Water free.

| | Composition of Fresh substance of cooked meat | | | | | Composition of Water-free substance in cooked meat | | | |
|---|---|---|---|---|---|---|---|---|---|
| Lab. No. | Water | Protein | Fat | Ash | Total | Protein | Fat | Ash | Total |
| 809a | 55.09 | 34.97 | 9.40 | 0.85 | 100.31 | 77.87 | 20.93 | 1.89 | 100.79 |
| 809b | 55.76 | 37.17 | 6.34 | 0.94 | 100.21 | 84.02 | 14.33 | 2.12 | 100.47 |

Cooking Experiment Number 23 (continued)

Table No.7

Percentage Loss of each Constituent in Cooking.

| Lab. No. 809 a | Total weight of nutrients in cooked meat | Broth | Raw Meat (calculated) | Percentage Loss of Each Nutrient | % Loss of each computed to fresh sample |
|---|---|---|---|---|---|
| Nitrog. Matter | 142.71 | 6.782 | 149.49 | 4.54 | 0.91 |
| Fat | 38.36 | 8.526 | 46.89 | 18.19 | 1.15 |
| Ash | 3.43 | 4.576 | 8.01 | 57.13 | 0.61 |
| Total | | 19.884 | | | 2.67 |

Total Loss, by direct weighing,- 45.1 %

Total loss of nutrients,- 2.67 %

Loss of water (by difference)- 42.43 %

| Lab. No. 809 b | | | | | |
|---|---|---|---|---|---|
| Nitrog. Matter | 141.25 | 6.541 | 147.79 | 4.43 | 0.95 |
| Fat | 24.10 | 5.342 | 29.44 | 18.15 | 0.78 |
| Ash | 3.57 | 4.460 | 8.03 | 55.54 | 0.65 |
| Total | | 16.343 | | | 2.38 |

Total Loss, by direct weighing,- 44.7 %

Total loss of nutrients,- 2.38 %

Loss of water (by difference)- 42.3 %

Method: Starting at boil, cooking two hours at 80°.

Remarks: Samples very well done and rather small.

Cooking Experiment Number 24.

Table No.1.

Total Loss in Weight by Cooking.

| Lab. No. | Wt. of Sample taken for Cooking | Wt. of Meat after Cooking | Loss in Weight by process of cooking | Percentage Loss in Cooking |
|---|---|---|---|---|
| 820 a | 915.10 | 784.7 | 130.4 | 14.3 |
| 820 b | 837.30 | 645.8 | 191.5 | 22.9 |

Table No.2.

Amount and Composition of Suspended Matter in Broths.

| Lab. No. | Wt. of Sample taken for Cooking | Combined Wt. of residues from filtration of broths | Wt. of Protein in Total Res. | Wt. of Fat in Total residues |
|---|---|---|---|---|
| 820 a | 915.1 | 5.890 | 4.419 | 1.333 |
| 820 b | 837.3 | 7.011 | 5.243 | 1.652 |

Table No.3.

Composition of Clear Filtered Broth.

| Broth from Lab. No. | Volume of Broth (c.c.) | Total Weight of Each Constituent of Filtered Broth. | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Total Solids by Direct Determination | Protein (Nx6.25) | Flesh Bases (Nx3.12) | Total Nitrog. Matter | Fat | Ash | Total by Summation |
| 820a | 2500 | 15.080 | 2.203 | 4.005 | 6.208 | 2.150 | 3.365 | 11.795 |
| 820b | " | 19.010 | 3.385 | 4.750 | 8.135 | 1.375 | 3.920 | 13.430 |

Cooking Experiment Number 24 (continued)

Table No.4.

Composition of Original Broth (Complete)

| Broth from Lab. No. | Wt. of Sample taken for cooking | Volume of Broth (c.c.) | Total Weight of Nutrients in Original Broth | | | | |
|---|---|---|---|---|---|---|---|
| | | | Protein (Nx6.25) | Fleah Bases (Nx3.12) | Total Nitrog. Matter | Fat | Ash |
| 820a | 915.1 | 2500 | 6.622 | 4.005 | 10.627 | 3.483 | 3.365 |
| 820b | 837.3 | " | 8.628 | 4.750 | 13.378 | 3.027 | 3.920 |

Table No.5.

Preparation and Analysis of Air-dried Material in Cooked Meat.

| Lab. No. | Preparation of Air-dried Material | | | Analysis of Air-dried Material | | | | |
|---|---|---|---|---|---|---|---|---|
| | Wt. of Sample taken for air-drying | water removed | | | | | | |
| | | Wt. in grams | per cent | Water | Protein | Fat | Ash | Total |
| 820a | 223.8 | 144.1 | 64.4 | 9.26 | 70.83 | 17.41 | 2.73 | 100.23 |
| 820b | 113.0 | 74.0 | 65.5 | 5.09 | 74.63 | 18.59 | 2.41 | 100.72 |

Table No.6.

Calculated Composition of Cooked Meat Fresh and Water free.

| Lab. No. | Composition of Fresh substance of cooked meat. | | | | | Composition of Water-free substance in cooked meat. | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Water | Protein | Fat | Ash | Total | Protein | Fat | Ash | Total |
| 820a | 68.14 | 24.87 | 6.11 | 0.96 | 100.08 | 78.06 | 19.18 | 3.01 | 100.25 |
| 820b | 66.40 | 26.42 | 6.58 | 0.85 | 100.25 | 78.63 | 19.59 | 2.54 | 100.76 |

Cooking Experiment Number 24 (continued)

Table No.7.

Percentage Loss of Each Constituent in Cooking.

| Lab. No. 820 a | Total Weight of Nutrients in cooked meat | Broth | Raw Meat (calculated) | Percentage Loss of Each Nutrient | % Loss of each computed to fresh raw samp. |
|---|---|---|---|---|---|
| Nitrog. Matter | 195.14 | 10.627 | 205.77 | 5.16 | 1.16 |
| Fat | 47.97 | 3.483 | 51.45 | 6.77 | 0.38 |
| Ash | 7.52 | 3.365 | 10.89 | 30.90 | 0.37 |
| Total | | 17.475 | | | 1.91 |

Total loss by direct weighing,- 14.25 %

Total loss of nutrients,- 1.91 %

Loss of water (by difference)- 12.34 %

| Lab. No. 820 b | | | | | |
|---|---|---|---|---|---|
| Nitrog. Matter | 170.62 | 13.378 | 184.00 | 7.27 | 1.59 |
| Fat | 42.49 | 3.027 | 45.52 | 6.65 | 0.36 |
| Ash | 5.50 | 3.920 | 9.42 | 41.61 | 0.47 |
| Total | | 20.325 | | | 2.42 |

Total loss by direct weighing,- 22.87 %

Total loss of Nutrients,- 2.42 %

Loss of Water (by difference)- 20.45 %

Method: Starting cold, cooking 5½ hours at 50° C.

Remarks: Samples rather large, not well cooked, very rare and juicy after cooking: Juice of meat separates during weighing and grinding, but was retained as completely as possible. Broth was thick with much suspended matter and filtered with difficulty.

Cooking Experiment Number 25.

Table No.1.

Total Loss in Weight by Cooking.

| Lab. No. | Wt. of Sample taken for Cooking | Wt. of Meat after Cooking | Loss in Weight by process of cooking | Percentage Loss in Cooking |
|---|---|---|---|---|
| 823 a | 798.1 | 461.4 | 336.7 | 42.2 |
| 823 b | 944.5 | 558.6 | 385.5 | 40.9 |

Table No.2.

Amount and Composition of Suspended Matter in Broths.

| Lab. No. | Wt. of Sample taken for Cooking | Combined Wt. of residues from filtration of broths | Wt. of Protein in total Residues | Wt. of Fat in Total residues |
|---|---|---|---|---|
| 823 a | 798.1 | 2.996 | 2.021 | 0.867 |
| 823 b | 944.5 | 6.761 | 1.832 | 4.649 |

Table No.3.

Composition of Clear Filtered Broth.

| Broth from Lab. No. | Volume of Broth (c.c.) | Total Weight of each Constituent of Filtered Broth. | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Total Solids by Direct Determination | Protein (Nx6.25) | Flesh Bases (Nx3.12) | Total Nitrog. Matter | Fat | Ash | Total by Summation |
| 823a | 2500 | 19.600 | 0.890 | 6.215 | 7.105 | 1.440 | 4.605 | 13.150 |
| 823b | " | 22.570 | 1.390 | 6.940 | 8.330 | 1.400 | 5.185 | 14.915 |

Cooking Experiment Number 25 (continued)

Table No.4.

Composition of Original Broth (Complete)

| Broth from Lab. No. | Wt. of Sample taken for cooking | Volume of Broth (c.c.) | Total Weight of Nutrients in Original Broth | | | | |
|---|---|---|---|---|---|---|---|
| | | | Protein (Nx6.25) | Flesh Bases (Nx3.12) | Total Nitrog. Matter | Fat | Ash |
| 823a | 798.1 | 2500 | 2.911 | 6.215 | 9.126 | 2.307 | 4.605 |
| 823b | 944.5 | " | 3.222 | 6.940 | 10.162 | 6.049 | 5.185 |

Table No.5.

Preparation and Analysis of Air-dried Material in Cooked Meat.

| Lab. No. | Preparation of Air-dried Material | | | Analysis of Air-dried Material | | | | |
|---|---|---|---|---|---|---|---|---|
| | Wt. of Sample taken for air-drying | water removed | | Water | Protein | Fat | Ash | Total |
| | | Wt. in grams | per cent | | | | | |
| 823a | 120.4 | 52.7 | 43.8 | 4.96 | 79.55 | 14.00 | 1.96 | 100.47 |
| 823b | 115.9 | 49.2 | 42.4 | 5.01 | 85.53 | 8.18 | 2.22 | 100.94 |

Table No.6.

Calculated Composition of Cooked Meat Fresh and Water free.

| Lab. No. | Composition of Fresh substance of cooked meat | | | | | Composition of Water free substance in cooked meat | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Water | Protein | Fat | Ash | Total | Protein | Fat | Ash | Total |
| 823a | 58.40 | 34.82 | 6.13 | 0.86 | 100.21 | 83.70 | 14.73 | 2.07 | 100.50 |
| 823b | 59.69 | 36.30 | 3.47 | 0.94 | 100.30 | 90.05 | 8.61 | 2.33 | 100.99 |

Cooking Experiment Number 25 (continued)

Table No.7.

Percentage Loss of Each Constituent in Cooking.

| Lab. No. 823 a | Total Weight of Nutrients in Cooked meat | Broth | Raw Meat (calculated) | Percentage Loss of Each Nutrient | % Loss of each computed to fresh raw samp. |
|---|---|---|---|---|---|
| Nitrog. Matter | 160.66 | 9.126 | 169.79 | 5.38 | 1.14 |
| Fat | 28.28 | ? | ? | ? | ? |
| Ash | 3.97 | 4.605 | 8.58 | 53.68 | 0.59 |
| Total | | " | | | |

Total Loss, by direct weighing,- 42.2 %

Total loss of nutrients,- "

Loss of water (by difference)- "

| Lab. No. 823 b | | | | | |
|---|---|---|---|---|---|
| Nitrog. Matter | 202.77 | 10.162 | 212.93 | 4.77 | 1.08 |
| Fat | 19.38 | 6.049 | 25.43 | 23.78 | 0.64 |
| Ash | 5.51 | 5.185 | 10.70 | 48.46 | 0.55 |
| Total | | 21.396 | | | 2.27 |

Total loss by direct weighing,- 40.85 %

Total loss of nutrients,- 2.27 %

Loss of water (by difference),- 38.58 %

Method: Starting cold, bringing gradually to boil, cooking two hours at 80°

Remarks: Method same as in Experiment No. 17. Meat well done, broth rather thick. Fat determination on residues from filtration of Sample A was lost by accident.

Summary of Results on Cooking Experiments.

| Lab. No. | Wt. of Sample Taken for Cooking (gms.) | Total Loss by Direct Weighing | % Loss of Nutrients Computed to fresh sample | Percentage Loss of Each Nutrient | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Computed to original amount of nutrient | | | Computed to fresh sample entire | | |
| | | | | Nitrog. Matter | Fat | Ash | Nitrog. Matter | Fat | Ash |
| 777a | 825.8 | 42.2 | 2.82 | 5.22 | 16.03 | 54.43 | 1.05 | 1.16 | 0.61 |
| 777b | 739.5 | 42.8 | 3.11 | 5.58 | 16.81 | 54.37 | 1.16 | 1.33 | 0.62 |
| 779a | 750.0 | 46.3 | 3.29 | 5.59 | 23.24 | 59.82 | 1.18 | 1.46 | 0.65 |
| 779b | 660.5 | 46.8 | 2.93 | 5.95 | 23.81 | 60.09 | 1.29 | 0.97 | 0.67 |
| 781a | 657.0 | 41.6 | 2.60 | 5.07 | 13.39 | 53.81 | 1.07 | 0.92 | 0.61 |
| 781b | 755.8 | 43.8 | 2.22 | 5.16 | 11.72 | 56.26 | 1.10 | 0.49 | 0.63 |
| 809a | 742.8 | 45.1 | 2.67 | 4.54 | 18.19 | 57.13 | 0.91 | 1.15 | 0.61 |
| 809b | 686.6 | 44.7 | 2.38 | 4.43 | 18.15 | 55.54 | 0.95 | 0.78 | 0.65 |
| 823a | 798.1 | 42.2 | ? | 5.38 | ? | 53.68 | 1.14 | ? | 0.59 |
| 823b | 944.5 | 40.9 | 2.27 | 4.77 | 23.78 | 48.46 | 1.08 | 0.64 | 0.55 |
| 771a | 705.5 | 41.1 | 2.50 | 6.07 | 16.60 | 56.79 | 1.08 | 0.85 | 0.57 |
| 771b | 660.8 | 41.3 | 2.96 | 5.22 | 19.79 | 53.97 | 1.14 | 1.23 | 0.59 |
| 820a | 915.1 | 14.3 | 1.91 | 5.16 | 6.57 | 30.90 | 1.16 | 0.38 | 0.37 |
| 820b | 837.3 | 22.9 | 2.42 | 7.27 | 6.65 | 41.61 | 1.59 | 0.36 | 0.47 |

General Conclusions from Cooking Experiments.

From the results of the eight experiments in which the meat was placed first in boiling water and then cooked two hours at 80° C., we may conclude that beef cooked in this way loses approximately 5.2 % of its nitrogenous matter, 17.7 % of its fat, and 56.4 % of its mineral matter. These constituents separated from the meat pass into the broth, being partly in solution and partly held in suspension in the liquid. The loss of fat varies greatly, being dependent upon the amount contained in the meat,— a greater amount sustaining a greater proportionate loss. These results agree well with those of the experiments made previously in this laboratory by similar methods, viz: a loss of one-sixteenth of the nitrogenous matter, one eighth of the fat, and one half of the ash. The higher figure obtained in our experiments for the loss of fat is due to the greater amount of visible fat present in our samples before cooking.

The size and thickness of the piece of meat cooked seems to influence the amount of loss in nutrients. The water penetrates farther into a small sample and dissolves more of the nutrient material than in the case of a larger sample. A sample of beef round, weighing about two pounds, when boiled in the manner above described, loses on an average 44 % of its weight; about 41.4 % of the original meat is, by cooking, removed as water, or in other words, nearly two thirds of the water in the beef is lost in cooking; the remainder of the total loss consists in the nutrients dissolved by the boiling process, which material is on an average 2.6 % of the original meat. About six or seven per cent of the or-

ganic nutrients is removed, and about 56 % of the mineral matter.

The results of the experiments in which the meat was placed first in cold water, raised gradually to the boiling point, and then cooked two hours at 80°, show the percentages loss of the different nutrients to be practically the same as in the first method of cooking described above. The figures for the amount of residue from filtration of the broths, show however that the amount of suspended, coagulated, nitrogenous matter in the broth is by this method much larger,— thus making a thicker and apparently richer soup.

The two experiments in which the meat was cooked 5 hours at 50° C. after starting in cold water are not very satisfactory as duplicates. The amount of fat and salts separated, however, is undoubtedly in this method considerably less than in the others on account of the low temperature, while the loss in nitrogenous matter is slightly more, appearing in the great amount of fine suspended matter in the soup. Soups prepared in this way are doubtless richer in nitrogenous matter of a nutritious nature, i.e. in proteids and proteoses, as distinguished from flesh bases which are not nutritious, than are soups prepared by the other methods described above; such soups are deficient however in fat and mineral salts.

# DIGESTION EXPERIMENTS.

## Introduction.

During the past ten years a considerable number of experiments have been made in this country on the natural digestion of food by man. More commonly, perhaps, until quite recently, have studies on digestion been made by artificial methods or if by natural methods, then with the lower animals rather than man.

The natural method of experimental inquiry into the digestibility of food is, without doubt, the most satisfactory method, and the only one giving results comparable with the true conditions of life; and yet it must be acknowledged that an experiment of this nature leaves much to be desired in any results which can give insight into the question of rapidity and ease of digestion. The actual amount of food digested is determined by measuring the quantity of food eaten and the quantity of undigested residue excreted in the faeces. In regard to the time necessary for the digestion of different kinds of food, and the comparative ease with which they are digested, no information is obtained by these methods.

Dr. W. O. Atwater of Wesleyan University has probably done more than any other investigator in this country to improve the methods and to intelligently interpret the results of natural digestion experiments with men. In his Bulletin 21, U. S. Depart-

ment of Agriculture, Office of Experiment Stations, he gives, in the course of a comprehensive treatise on the digestibility of foods, an historical summary of the subject, a discussion of methods, and a statement of the needs, at that time,(1894) for further research. The first experiments of this kind which he mentions as being of any importance, were those of Rubner, in 1876, at the Munich Physiological Laboratory. Since then there has been considerable activity in Germany and other foreign countries along this line. Dr. Atwater gives a comprehensive outline of the history of such investigations, adding a tabulated statement of the results obtained by different experimenters. (17.)

Since the publication of this bulletin, Atwater has himself made many digestion experiments at the Connecticut Storrs Experiment Station, (18.) and under his direction, as special agent of the U. S. Dep't of Agri. on the subject of Food and Nutrition of Man, a great deal of work has been done by other Experiment Stations throughout the country. Prof. Woods of Maine conducted experiments in 1894 - 1897, comparing the digestibility of different kinds of bread; (19.) Prof. Wait of Tennessee performed a series of natural digestion experiments in 1895 - 1897, on a mixed diet (20.) ; Prof. Snyder of Minnesota experimented in 1896 - 1898 on the digestibility of potatoes and eggs, and different kinds of bread (21.) ; Dr. Atwater carried on ir 1894 - 1897 an extensive series of natural digestion experiments on mixed diet at the Conn. Storrs Experiment Station (18.) ,besides many others recently in connection with elaborate metabolism experiments in the " Respiration Calorimeter." (22.)

Of the experiments above mentioned, some have been of a com-

parative nature, notably those at the Maine and Minnesota stations on bread. European investigators have endeavored also to obtain comparative results on the digestibility of different kinds of bread, (23.) , of different fats (24.) , of rice and macaroni (25.) ; and one, Förster, has studied the nutritive value and digestibility of beef when cooked in different ways. (26.) We have not found record of any experiments in this country made with the object of comparing the digestibility of meat when cooked in different ways. The importance of this question has been thus stated by Dr. Atwater (27.) : "One of the most important practical topics now demanding investigation, is the effect of cooking on the digestibility and nutritive value of food materials."

Experiments have been made in this laboratory by Dr. H..S. Grindley, previous to the work reported in this thesis, viz: in the summer of 1899, in which comparative results were obtained on boiled and fried beef.

In this thesis, we report the results of a series of eight experiments conducted during the winter and spring of 1899 - 1900, with the object of comparing the digestibility of beef when cooked by different methods. The conditions of the experiments were maintained as nearly as possible the same throughout the series, with the exception of the one condition, the effect of which variation it was desired to note,— this being of course the method of cooking the beef. With this end in view the same person necessarily acted as subject throughout the series, and the same kinds and amounts of food were eaten, with the exception of the meat. An effort was made also to keep the daily routine of the subject, the amount of exercise taken, and other minor details influencing the

experiment, the same in all.

It may be assumed then, that any variation in the coefficients of digestibility obtained in the different experiments is due to the variation in the character of the beef. Prof. Woods, however, in his experiments comparing the digestibility of different breads, has calculated the actual coefficients for the bread itself (eaten in a mixed diet), by assuming arbitrary coefficients for the other articles of diet, computed from a great many previous experiments of others. This seems hardly necessary in our experiments since all conditions but the one were kept the same throughout, and this varying condition should be the chief cause of any variation in results.

The mechanical manipulations followed were essentially those of Atwater, as described in his bulletins. (17), (18). The difference between the total amount of food eaten by the subject during the period of the experiment and the total indigestible or unassimilated portion as represented by the faeces is regarded as the amount of food digested and assimilated. The faeces contain small quantities of other matter in addition to the undigested residues of the food,— this being, viz; metabolic products such as mucus, residues of digestive juices, etc. But the error involed here is small, and may be disregarded, especially if we consider these metabolic products as not available to the system in building tissue or yielding energy and hence properly to be classed as indigestible material. We use thus, the word " digestibility" in the sense of " availability ". For further opinions on this subject see Editorial in Exp't Sta. Rec. Vol. 6 No. 3., and references (28). and (29).

Preliminary observations and measurements were made to

determine the amounts of food desirable for the subject. Experiment Number 11 may be regarded as preliminary and not of the comparative series. Each food material was prepared in sufficient quantity for the period, a representative sample taken for analysis, and portions for food accurately weighed into quick-sealing glass fruit jars. All the food necessary was thus prepared previous to the beginning of the experiment. The methods used for analysis of foods and faeces were the Official Methods of the Association of Official Agricultural Chemists. A representative sample of the entire, well-mixed, lot was taken for analysis and, if not quite dry, was subjected to the process of air-drying before analyzing completely.

To separate the faeces belonging to the period of the experiment, a meal of bread and milk with three lamp-black capsules (containing about 0.5 gram), was eaten immediately before and immediately after the period. The faeces from these meals are colored black.

The total amount of urine for the period of the experiment was collected in 24 hour portions, the "Nitrogen Lag" being regarded as 12 hours, and the nitrogen determined in each lot. By comparing the total nitrogen in the food, with that excreted in urine and faeces, the balance of income and outgo of nitrogen may be observed or any gain or loss of protein noted. The subject was weighed, stripped, on the first morning of the experiment and again on the morning next after the close of the experiment.

The following tables need no explanation.

Table No.1.

Composition of Foods and Faeces in following Digestion Exp'ts.

(analyses of fresh substance, free from refuse.)

| Lab. No. | Exp't No. | Material | Water | Pro-tein | Fat | Carbo-hydrates | Ash |
|---|---|---|---|---|---|---|---|
| 609 | 16-19 | Sugar | 0.35 | ---- | --- | 99.65 | --- |
| 788 | 11-15 | " | ---- | ---- | --- | 100.00 | --- |
| 787 | 11 | B'f't Food | 11.88 | 12.54 | 0.94 | 74.13 | 0.51 |
| 797 | 12-19 | Rolled Oats | 8.82 | 14.51 | 7.24 | 67.61 | 1.82 |
| 789 | 11 | Milk | 86.62 | 3.55 | 4.33 | 4.74 | 0.76 |
| 801 | 12 | " | 87.11 | 3.46 | 4.36 | 4.31 | 0.76 |
| 812 | 13 | " | 88.37 | 2.67 | 3.37 | 4.84 | 0.75 |
| 829 | 14 | " | 87.75 | 2.78 | 3.57 | 5.16 | 0.74 |
| 838 | 15 | " | 87.59 | 2.79 | 4.21 | 4.70 | 0.71 |
| 853 | 16 | " | 86.88 | 2.77 | 4.36 | 5.27 | 0.72 |
| 865 | 17 | " | 86.90 | 3.04 | 4.74 | 4.60 | 0.72 |
| 875 | 18 | " | 88.15 | 2.48 | 3.84 | 4.86 | 0.69 |
| 886 | 19 | " | 87.72 | 2.63 | 3.83 | 5.13 | 0.69 |
| 786 | 11 | Butter | 10.50 | 0.69 | 86.61 | ------ | 2.20 |
| 802 | 12 | " | 7.13 | 0.80 | 90.74 | ----- | 1.33 |
| 813 | 13 | " | 12.32 | 0.40 | 84.55 | ----- | 2.73 |
| 828 | 14 | " | 9.28 | 0.38 | 88.29 | ----- | 2.05 |
| 837 | 15 | " | 9.01 | 0.54 | 87.39 | ----- | 3.06 |
| 852 | 16 | " | 8.17 | 0.60 | 89.03 | ----- | 2.20 |
| 864 | 17 | " | 9.31 | 0.56 | 88.80 | ----- | 1.33 |
| 874 | 18 | " | 8.53 | 0.64 | 89.75 | ----- | 1.08 |
| 885 | 19 | " | 6.42 | 0.81 | 90.32 | ----- | 2.45 |
| 785 | 11 | Bread | 44.19 | 7.39 | 0.89 | 46.67 | 0.86 |
| 799 | 12 | " | 44.20 | 7.76 | 0.48 | 46.27 | 1.29 |
| 810 | 13 | " | 44.37 | 7.53 | 1.36 | 46.91 | 0.83 |
| 826 | 14 | " | 41.59 | 9.04 | 1.16 | 47.46 | 0.75 |
| 840 | 15 | " | 42.55 | 8.40 | 1.11 | 47.14 | 0.80 |
| 850 | 16 | " | 42.00 | 8.52 | 1.31 | 47.42 | 0.75 |
| 862 | 17 | " | 41.42 | 8.06 | 0.88 | 48.76 | 0.88 |
| 872 | 18 | " | 44.84 | 8.30 | 0.71 | 45.49 | 0.66 |
| 882 | 19 | " | 42.53 | 8.76 | 0.85 | 47.17 | 0.69 |

| Lab. No. | Exp't No. | Material | Water | Protein | Fat | Carbohydrates | Ash |
|---|---|---|---|---|---|---|---|
| 784 | 11 | Baked Beans | 66.69 | 7.23 | 1.39 | 22.19 | 2.50 |
| 800 | 12 | " " | 66.07 | 7.53 | 0.94 | 22.95 | 2.51 |
| 811 | 13 | " " | 66.17 | 7.34 | 1.18 | 22.61 | 2.70 |
| 827 | 14 | " " | 66.03 | 7.43 | 1.97 | 22.06 | 2.51 |
| 841 | 15 | " " | 66.97 | 6.97 | 1.46 | 21.91 | 2.69 |
| 851 | 16 | " " | 67.34 | 6.96 | 1.53 | 22.03 | 2.15 |
| 863 | 17 | " " | 65.61 | 7.40 | 1.06 | 23.29 | 2.64 |
| 873 | 18 | " " | 66.22 | 7.54 | 0.95 | 22.50 | 2.79 |
| 883 | 19 | " " | 66.51 | 8.59 | 1.21 | 20.96 | 2.73 |
| 783 | 11 | Beef | 56.98 | 35.71 | 4.97 | ----- | 2.01 |
| 798 | 12 | " | 54.68 | 35.09 | 7.97 | ----- | 1.82 |
| 809c | 13 | " | 53.73 | 36.13 | 7.51 | ----- | 2.81 |
| 825 | 14 | " | 64.12 | 26.64 | 6.74 | ----- | 2.28 |
| 839 | 15 | " | 64.83 | 26.07 | 5.72 | ----- | 1.58 |
| 849 | 16 | " | 62.30 | 28.64 | 6.86 | ----- | 1.67 |
| 861 | 17 | " | 60.71 | 32.61 | 5.25 | ----- | 1.61 |
| 871 | 18 | " | 66.39 | 23.24 | 8.43 | ----- | 1.31 |
| 884 | 19 | " | 62.96 | 27.97 | 7.18 | ----- | 1.45 |
| 794 | 11 | Faeces* | 6.21 | 37.77 | 10.71 | 28.00 | 17.31 |
| 807 | 12 | " | 6.62 | 39.20 | 9.30 | 27.68 | 17.20 |
| 818 | 13 | " | 7.26 | 36.30 | 12.21 | 26.61 | 17.62 |
| 834 | 14 | " | 7.05 | 37.13 | 7.87 | 29.54 | 18.41 |
| 846 | 15 | " | 7.71 | 37.12 | 10.27 | 27.59 | 17.31 |
| 858 | 16 | " | 6.67 | 37.74 | 10.12 | 27.77 | 17.70 |
| 870 | 17 | " | 7.46 | 40.46 | 11.44 | 23.52 | 17.12 |
| 880 | 18 | " | 8.53 | 41.37 | 12.41 | 21.51 | 16.18 |
| 891 | 19 | " | 9.12 | 43.00 | 11.25 | 21.09 | 15.54 |

* air-dried at 60° C.

## Digestion Experiment No. 11.

Preliminary to series.

Kind of food: Mixed diet; beef round, cooked by placing in boiling water and then cooking two hours at 80° C., seasoned with salt and pepper.

Subject: Chemist, 24 years old, with active work about the laboratory and regular physical exercise daily. Weight (without clothing), at beginning of experiment 136.2, and at end of experiment 136 pounds. Duration: Four days with 12 meals beginning with breakfast, December 21, 1899.

Table No.2. Results of Experiment No. 11.

| Lab. No. | Food Material | Weight of Material | Total Organic Matter | Protein (N x 6.25) | Fat | Carbohydrates | Ash |
|---|---|---|---|---|---|---|---|
| 788 | Sugar | 120 | 120.0 | ---- | --- | 120.00 | --- |
| 786 | Butter | 180 | 157.1 | 1.23 | 155.91 | ------ | 3.96 |
| 789 | Milk | 2486.4 | 313.8 | 88.27 | 107.66 | 117.86 | 18.90 |
| 787 | B'f't Food | 140 | 122.6 | 17.56 | 1.32 | 103.78 | 0.71 |
| 784 | Beans | 880 | 271.1 | 63.62 | 12.23 | 195.27 | 22.05 |
| 785 | Bread | 780 | 428.4 | 57.64 | 6.74 | 364.03 | 6.71 |
| 783 | Beef | 400 | 163.0 | 142.84 | 19.88 | ------ | 8.04 |
| | Total | | 1576.1 | 371.16 | 303.74 | 902.27 | 60.37 |
| 794 | Faeces | 58.36 | 44.63 | 22.04 | 6.25 | 16.34 | 10.10 |
| | Amount Digested | | 1531.46 | 349.12 | 297.49 | 885.93 | 50.27 |
| | Per cent Digested | | 97.2 | 94.1 | 97.9 | 98.2 | 83.3 |

Income and Outgo of Nitrogen, Exp't No. 11.

| Period (1 P.M.-1 P.M.) | Weight of Urine | Nitrogen in Urine % | Nitrogen in Urine grams | N in Faeces grams | N in Food grams | Gain(+) or Loss(−) N grams | Gain(+) or Loss(−) Protein grams |
|---|---|---|---|---|---|---|---|
| Dec.21 - 22 | 1203.6 | 1.29 | 15.53 | 0.89 | 14.85 | -1.56 | |
| Dec.22 - 23 | 821.3 | 1.93 | 15.85 | 0.88 | 14.85 | -1.88 | |
| Dec.23 - 24 | 1219.8 | 1.48 | 18.05 | 0.88 | 14.85 | -4.09 | |
| Dec.24 - 25 | 1149.7 | 1.22 | 14.03 | 0.88 | 14.85 | -0.06 | |
| Total | | | 63.46 | 3.53 | 59.40 | -7.59 | -47.4 |

## Digestion Experiment No. 12.

Kind of Food: Mixed diet. Beef cooked as in Exp't No. 11. Subject: same. Weight: (without clothing), at beginning of experiment 137.3, and at end of experiment 136.7 pounds. Duration: Four days with 12 meals beginning with breakfast, January 3, 1900.

Table No.3. Results of Experiment No. 12.

| Lab. No. | Food Material | Weight of Material | Total Organic Matter | Protein (N x 6.25) | Fat | Carbohydrates | Ash |
|---|---|---|---|---|---|---|---|
| 788 | Sugar | 120 | 120. | ---- | --- | 120.00 | --- |
| 802 | Butter | 180 | 164.8 | 1.44 | 163.33 | ------ | 2.40 |
| 801 | Milk | 2486.4 | 301.6 | 86.03 | 108.41 | 107.16 | 18.90 |
| 797 | Rolled Oats | 140 | 125.1 | 20.31 | 10.14 | 94.65 | 2.55 |
| 800 | Beans | 840 | 263.9 | 63.25 | 7.90 | 192.78 | 21.08 |
| 799 | Bread | 840 | 457.9 | 65.18 | 4.03 | 388.67 | 10.84 |
| 798 | Beef | 400 | 174.0 | 140.36 | 31.88 | ------ | 7.28 |
| | Salt | 7.66 | ----- | ----- | ------ | ------ | 7.66 |
| | Total | | 1607.3 | 376.58 | 325.69 | 905.03 | 70.70 |
| 807 | Faeces | 76.46 | 58.25 | 29.97 | 7.11 | 21.17 | 13.15 |
| | Amount Digested | | 1549.05 | 346.61 | 318.58 | 883.86 | 57.55 |
| | Per cent Digested | | 96.4 | 92.0 | 97.8 | 97.7 | 81.4 |

Income and Outgo of Nitrogen, Exp't No. 12.

| Period 7 P.M. - 7 P.M. | Weight of Urine | Nitrogen in Urine % | Nitrogen in Urine grams | N in Faeces grams | N in Food grams | Gain(+) or Loss(−) N grams | Gain(+) or Loss(−) Protein grams |
|---|---|---|---|---|---|---|---|
| Jan.3 - 4 | 797.8 | 1.88 | 15.00 | 1.19 | 15.85 | -0.34 | |
| Jan.4 - 5 | 846.2 | 1.93 | 16.33 | 1.20 | 15.85 | -1.68 | |
| Jan.5 - 6 | 924.0 | 1.79 | 16.54 | 1.20 | 15.85 | -1.89 | |
| Jan.6 - 7 | 1607.4 | 1.01 | 16.24 | 1.20 | 15.85 | -1.58 | |
| Total | | | 64.11 | 4.79 | 63.41 | -5.49 | -34.3 |

## Digestion Experiment No. 13.

Duplicate of No. 12.

Kind of Food: Mixed diet. Beef cooked as in No. 12.

Subject: same. Weight: (without clothing), at beginning of experiment 136.7, and at end of experiment 135.4 pounds.

Duration: Four days with 12 meals beginning with breakfast January 23, 1900.

Table No.4. Results of Experiment No. 13.

| Lab. No. | Food Material | Weight of Material | Total Organic Matter | Protein (N x 6.25) | Fat | Carbohydrates | Ash |
|---|---|---|---|---|---|---|---|
| 788 | Sugar | 120 | 120.00 | ---- | ---- | 120.00 | --- |
| 813 | Butter | 180 | 152.9 | 0.72 | 152.19 | ------ | 4.91 |
| 812 | Milk | 2484. | 270.3 | 66.32 | 83.71 | 120.23 | 18.63 |
| 797 | Rolled Oats | 140 | 125.1 | 20.31 | 10.14 | 94.65 | 2.55 |
| 811 | Beans | 840 | 261.3 | 61.66 | 9.71 | 189.92 | 22.68 |
| 810 | Bread | 840 | 467.7 | 63.25 | 11.42 | 393.04 | 6.97 |
| 809c | Beef | 400 | 174.6 | 144.52 | 30.04 | ------ | 11.24 |
| | Salt | 7.3 | ----- | ----- | ----- | ------ | 7.30 |
| | Total | | 1571.9 | 356.78 | 297.21 | 917.84 | 74.28 |
| 818 | Faeces | 42.95 | 32.3 | 15.59 | 5.24 | 11.43 | 7.57 |
| | Amount Digested | | 1539.6 | 341.19 | 291.97 | 906.41 | 66.71 |
| | Per cent Digested | | 97.9 | 95.6 | 98.3 | 98.8 | 89.8 |

Income and Outgo of Nitrogen, Exp't No. 13.

| Period 7 P.M.-7 P.M. | Weight of Urine | Nitrogen in Urine % | Nitrogen in Urine grams | N in Faeces grams | N in Food grams | Gain(+) or Loss(--) N grams | Protein grams |
|---|---|---|---|---|---|---|---|
| Jan.23 - 24 | 757.4 | 1.92 | 14.54 | 0.62 | 14.27 | -0.89 | |
| Jan.24 - 25 | 866.3 | 1.87 | 16.20 | 0.62 | 14.27 | -2.55 | |
| Jan.25 - 26 | 938.6 | 1.73 | 16.24 | 0.63 | 14.27 | -2.60 | |
| Jan.26 - 27 | 849.9 | 1.83 | 15.55 | 0.63 | 14.26 | -1.92 | |
| Total | | | 62.53 | 2.50 | 57.07 | -7.96 | -49.8 |

Digestion Experiment No. 14.

Kind of Food: Mixed diet. Beef round, passed through sausage mill and made into balls; cooked by frying 10 minutes in little melted butter, until mediumly well done; seasoned with salt and pepper.

Subject: same. Weight: (without clothing), at beginning of experiment 137.5 and at end of experiment 135.5 pounds. Duration: Four days with 12 meals beginning with breakfast, Februrary 20, 1900.

Table No.5. Results of Experiment No. 14.

| Lab. No. | Food Material | Weight of Material | Total Organic Matter | Protein (N x 6.25) | Fat | Carbohydrates | Ash |
|---|---|---|---|---|---|---|---|
| 788 | Sugar | 120 | 120.00 | ---- | ---- | 120.00 | ---- |
| 828 | Butter | 180 | 159.60 | 0.68 | 158.92 | ----- | 3.69 |
| 829 | Milk | 2484. | 284.81 | 68.06 | 88.58 | 128.17 | 18.38 |
| 797 | Rolled Oats | 140 | 125.10 | 20.31 | 10.14 | 94.65 | 2.55 |
| 827 | Beans | 840 | 264.36 | 62.51 | 16.55 | 185.30 | 21.08 |
| 826 | Bread | 840 | 484.34 | 75.94 | 9.74 | 398.66 | 6.30 |
| 825 | Beef | 400 | 133.52 | 106.56 | 26.96 | ----- | 9.12 |
| | Salt | 9.4 | ------ | ----- | ----- | ------ | 9.42 |
| | Total | | 1571.73 | 334.06 | 310.89 | 926.78 | 70.54 |
| 834 | Faeces | 34.0 | 25.46 | 12.62 | 2.78 | 10.06 | 5.28 |
| | Amount Digested | | 1546.27 | 321.44 | 308.11 | 916.72 | 65.26 |
| | Per cent Digested | | 98.4 | 96.2 | 99.1 | 98.9 | 92.5 |

Income and Outgo of Nitrogen, Exp't No. 14.

| Period 1 P.M.-1 P.M. | Weight of Urine | Nitrogen in Urine % | Nitrogen in Urine grams | N in Faeces grams | N in Food grams | Gain(+) or Loss(--) N grams | Gain(+) or Loss(--) Protein grams |
|---|---|---|---|---|---|---|---|
| Feb.20 - 21 | 785.5 | 1.89 | 14.85 | 0.50 | 13.36 | -1.99 | |
| Feb.21 - 22 | 858.5 | 1.75 | 15.02 | 0.50 | 13.36 | -2.16 | |
| Feb.22 - 23 | 855.3 | 1.59 | 13.60 | 0.51 | 13.36 | -0.75 | |
| Feb.23 - 24 | 825.5 | 1.69 | 13.95 | 0.51 | 13.37 | -1.09 | |
| Total | | | 57.42 | 2.02 | 53.45 | -5.99 | -37.4 |

## Digestion Experiment No. 15.

Duplicate of No. 14.

Kind of Food: Mixed diet: beef cooked as in Exp't 14.

Subject: same. Weight: (without clothing), at beginning of experiment 137.6, and at end of experiment 136.0 pounds. Duration: Four days with 12 meals beginning with breakfast, March 12, 1900.

Table No. 6. Results of Experiment No. 15.

| Lab. No. | Food Material | Weight of Material | Total Organic Matter | Protein (N x 6.25) | Fat | Carbohydrates | Ash |
|---|---|---|---|---|---|---|---|
| 788 | Sugar | 120 | 120.00 | ---- | ---- | 120.00 | --- |
| 837 | Butter | 180 | 158.27 | 0.97 | 157.30 | ----- | 5.51 |
| 838 | Milk | 2480.4 | 294.62 | 73.30 | 104.58 | 116.74 | 17.64 |
| 797 | Rolled Oats | 140 | 125.36 | 20.31 | 10.14 | 94.65 | 2.55 |
| 841 | Beans | 840 | 255.40 | 58.55 | 12.26 | 184.63 | 22.60 |
| 840 | Bread | 840 | 475.96 | 70.56 | 9.32 | 395.98 | 6.72 |
| 839 | Beef | 400 | 127.16 | 104.28 | 22.88 | ------ | 6.32 |
| | Salt | 8.7 | ----- | ----- | ----- | ------- | 8.70 |
| | Total | | 1556.8 | 328.00 | 316.48 | 912.00 | 70.04 |
| 846 | Faeces | 26.49 | 21.2 | 9.83 | 2.72 | 8.64 | 4.59 |
| | Amount Digested | | 1535.6 | 318.17 | 313.76 | 903.36 | 65.45 |
| | Per cent Digested | | 98.6 | 97.0 | 99.1 | 99.1 | 93.5 |

Income and Outgo of Nitrogen, Exp't No. 15.

| Period 1 P.M.-1 P.M. | Weight of Urine | Nitrogen in Urine % | Nitrogen in Urine grams | N in Faeces grams | N in Food grams | Gain(+) or Loss(--) N grams | Gain(+) or Loss(--) Protein grams |
|---|---|---|---|---|---|---|---|
| Mar.12 - 13 | 770.8 | 1.55 | 11.95 | 0.39 | 13.14 | +0.80 | |
| Mar.13 - 14 | 846.8 | 1.64 | 13.88 | 0.39 | 13.14 | -1.13 | |
| Mar.14 - 15 | 954.1 | 1.45 | 13.84 | 0.39 | 13.13 | -1.09 | |
| Mar.15 - 16 | 862.5 | 1.49 | 12.85 | 0.40 | 13.13 | -0.12 | |
| Total | | | 52.52 | 1.57 | 52.54 | -1.54 | -9.63 |

Digestion Experiment No. 16.

Kind of Food: Mixed diet. Beef round, cooked by placing in boiling water and then cooking 20 minutes at 80° C., seasoned with salt and pepper; cooked beef, juicy and rare but tough.

Subject: same. Weight: (without clothing), at beginning of experiment 137.8, and at end of experiment 135.3 pounds.

Duration: Four days with 12 meals beginning with breakfast, March 26, 1900.

Table No.7. Results of Exp't No. 16.

| Lab. No. | Food Material | Weight of Material | Total Organic Matter | Protein (N x 6.25) | Fat | Carbohydrates | Ash |
|---|---|---|---|---|---|---|---|
| 609 | Sugar | 120 | 119.6 | ---- | --- | 119.58 | ---- |
| 852 | Butter | 180 | 161.3 | 1.08 | 160.25 | ----- | 3.96 |
| 853 | Milk | 2481.6 | 297.7 | 68.74 | 108.20 | 120.79 | 17.87 |
| 797 | Rolled Oats | 140 | 125.4 | 20.31 | 10.40 | 94.65 | 2.55 |
| 851 | Beans | 840 | 256.4 | 58.46 | 12.85 | 185.05 | 18.06 |
| 850 | Bread | 840 | 480.9 | 71.57 | 11.00 | 398.33 | 6.30 |
| 849 | Beef | 400. | 142.0 | 114.56 | 27.44 | ----- | 6.68 |
| | Salt | 7.6 | ----- | ----- | ----- | ------ | 7.56 |
| | Total | | 1583.3 | 334.72 | 330.19 | 918.40 | 62.98 |
| 858 | Faeces | 48.5 | 36.7 | 18.31 | 4.91 | 13.47 | 8.59 |
| | Amount Digested | | 1546.6 | 316.41 | 325.28 | 904.93 | 54.39 |
| | Per cent Digested | | 97.7 | 94.6 | 98.5 | 98.5 | 86.4 |

Income and Outgo of Nitrogen, Exp't No. 16.

| Period 1 P.M.-1 P.M. | Weight of Urine | Nitrogen in Urine % | Nitrogen in Urine grams | N in Faeces grams | N in Food grams | Gain(+) or Loss(--) N grams | Protein grams |
|---|---|---|---|---|---|---|---|
| Mar.26 - 27 | 661.4 | 1.84 | 12.26 | 0.73 | 13.39 | +0.40 | |
| Mar.27 - 28 | 1044.2 | 1.45 | 15.14 | 0.73 | 13.39 | -2.48 | |
| Mar.28 - 29 | 997.6 | 1.29 | 12.87 | 0.73 | 13.39 | -0.21 | |
| Mar.29 - 30 | 884.8 | 1.60 | 14.16 | 0.74 | 13.39 | -1.51 | |
| Total | | | 54.43 | 2.93 | 53.56 | -3.80 | -23.8 |

## Digestion Experiment No. 17.

Duplicate of No. 16.

Kind of Food: Mixed diet. Beef cooked as in Exp't 16.

Subject: same. Weight: (without clothing), at beginning of experiment 136.3 and at end of experiment, 134.5 pounds.

Duration: Four days with 12 meals beginning with breakfast, April 9, 1900.

Table No.8. Results of Experiment No. 17.

| Lab. No. | Food Material | Weight of Material | Total Organic Matter | Protein (N x 6.25) | Fat | Carbohydrates | Ash |
|---|---|---|---|---|---|---|---|
| 609 | Sugar | 120 | 119.9 | ---- | ---- | 119.85 | --- |
| 864 | Butter | 180 | 160.9 | 1.01 | 159.84 | ----- | 2.39 |
| 865 | Milk | 2480.4 | 307.1 | 75.40 | 117.57 | 114.10 | 17.86 |
| 797 | Rolled Oats | 140 | 125.4 | 20.31 | 10.40 | 94.65 | 2.55 |
| 863 | Beans | 840 | 516.5 | 62.16 | 8.90 | 423.28 | 22.18 |
| 862 | Bread | 840 | 492.0 | 67.70 | 7.39 | 409.58 | 7.39 |
| 861 | Beef | 400 | 151.4 | 130.44 | 21.00 | ------ | 6.44 |
| | Salt | 7.2 | ----- | ----- | ----- | ---- | 7.18 |
| | Total | | 1873.2 | 357.02 | 325.10 | 1161.46 | 65.99 |
| 870 | Faeces | 27.21 | 25.18 | 11.01 | 3.11 | 6.40 | 4.66 |
| | Amount Digested | | 1848.0 | 346.01 | 321.99 | 1155.06 | 61.33 |
| | Per cent Digested | | 98.65 | 96.9 | 99.0 | 99.5 | 92.9 |

Income and Outgo of Nitrogen, Exp't No. 17.

| Period 1 P.M.-1 P.M. | Weight of Urine | Nitrogen in Urine % | Nitrogen in Urine grams | N in Faeces grams | N in Food grams | Gain(+) or Loss(--) N grams | Protein grams |
|---|---|---|---|---|---|---|---|
| April 9 - 10 | 779.5 | 1.55 | 12.08 | 0.44 | 14.28 | +1.76 | |
| April 10-11 | 908.5 | 1.62 | 14.72 | 0.44 | 14.28 | -0.88 | |
| April 11-12 | 1052.8 | 1.41 | 14.84 | 0.44 | 14.28 | -1.00 | |
| April 12-13 | 796.9 | 1.71 | 13.63 | 0.44 | 14.28 | +0.21 | |
| Total | | | 55.27 | 1.76 | 57.12 | +0.09 | +0.56 |

Digestion Experiment No. 18.

Kind of Food: Mixed diet. Beef round, cooked by roasting or broiling, in large piece, searing surface for two or three minutes, and then cooking 20 minutes, until mediumly well done; seasoned with salt and pepper.

Subject: same. Weight: (without clothing), at beginning of experiment 138.2, and at end of experiment, 135.2 pounds. Duration: Four days with 12 meals, beginning with breakfast, April 23, 1900.

Table No.9. Results of Experiment No. 18.

| Lab. No. | Food Material | Weight of Material | Total Organic Matter | Protein (N x 6.25) | Fat | Carbohydrates | Ash |
|---|---|---|---|---|---|---|---|
| 609 | Sugar | 120 | 119.9 | ----- | ---- | 119.85 | --- |
| 874 | Butter | 180 | 162.7 | 1.15 | 161.55 | ----- | 1.94 |
| 875 | Milk | 2478. | 277.0 | 61.45 | 95.16 | 120.43 | 17.10 |
| 797 | Rolled Oats | 140 | 125.4 | 20.31 | 10.40 | 94.65 | 2.55 |
| 873 | Beans | 840 | 260.2 | 63.34 | 7.98 | 189.00 | 23.44 |
| 872 | Bread | 840 | 457.8 | 69.72 | 5.96 | 382.12 | 5.54 |
| 871 | Beef | 400 | 126.7 | 92.96 | 33.72 | ------ | 5.24 |
| | Salt | 8.0 | ----- | ----- | ----- | ----- | 8.01 |
| | Total | | 1529.65 | 308.93 | 314.77 | 906.05 | 63.82 |
| 880 | Faeces | 50.0 | 37.66 | 20.69 | 6.21 | 10.76 | 8.09 |
| | Amount Digested | | 1491.99 | 288.24 | 308.56 | 895.29 | 55.73 |
| | Per cent Digested | | 97.5 | 93.3 | 98.0 | 98.8 | 87.3 |

Income and Outgo of Nitrogen, Exp't No. 18.

| Period 1 P.M.-1 P.M. | Weight of Urine | Nitrogen in Urine % | Nitrogen in Urine grams | N in Faeces grams | N in Food grams | Gain(+) or Loss(—) N grams | Protein grams |
|---|---|---|---|---|---|---|---|
| April 23-24 | 792.4 | 1.37 | 10.86 | 0.83 | 12.36 | +0.67 | |
| April 24-25 | 1054.3 | 1.28 | 13.50 | 0.83 | 12.36 | -1.97 | |
| April 25-26 | 901.0 | 1.37 | 12.34 | 0.83 | 12.36 | -0.81 | |
| April 26-27 | 792.9 | 1.51 | 11.97 | 0.82 | 12.35 | -0.44 | |
| Total | | | 48.67 | 3.31 | 49.43 | -2.55 | -15.94 |

Digestion Experiment No. 19.

Duplicate of No. 18.

Kind of Food: Mixed diet. Beef cooked as in Exp't No. 18.

Subject: same. Weight (without clothing), at beginning of experiment 137.0 and at end of experiment 133.8 pounds.

Duration: Four days with 12 meals beginning with breakfast, May 8, 1900.

Table No.10. Results of Experiment No. 19.

| Lab. No. | Food Material | Weight of Material | Total Organic Matter | Protein (N x 6.25) | Fat | Carbohydrates | Ash |
|---|---|---|---|---|---|---|---|
| 609 | Sugar | 120 | 119.85 | ----- | --- | 119.85 | ---- |
| 885 | Butter | 180 | 164.03 | 1.46 | 162.58 | ----- | 4.41 |
| 886 | Milk | 2481.6 | 287.63 | 65.27 | 95.05 | 127.31 | 17.02 |
| 797 | Rolled Oats | 140 | 125.36 | 20.31 | 10.40 | 94.65 | 2.55 |
| 883 | Beans | 840 | 260.38 | 74.16 | 10.16 | 176.06 | 22.93 |
| 882 | Bread | 840 | 479.15 | 75.58 | 7.34 | 396.23 | 5.80 |
| 884 | Beef | 400 | 140.60 | 111.88 | 28.72 | ------ | 5.80 |
| | Salt | 10.9 | ----- | ----- | ----- | ----- | 10.85 |
| | Total | | 1577.0 | 348.66 | 314.25 | 914.10 | 69.36 |
| 891 | Faeces | 48.7 | 36.7 | 20.94 | 5.48 | 10.27 | 7.57 |
| | Amount Digested | | 1540.31 | 327.72 | 308.77 | 903.83 | 61.79 |
| | Per cent Digested | | 97.7 | 94.0 | 98.3 | 98.9 | 89.1 |

Results for Income and Outgo of Nitrogen, lost.

Table No. 11.

Summary of the Series of Digestion Experiments here reported, and some results of other investigators for comparison.

| Exp't No. | Description. | Per cent Digested | | | | |
|---|---|---|---|---|---|---|
| | | Total Organic Matter | Protein | Fat | Carbohydrates | Ash |
| 12 | Mixed diet; beef | 96.4 | 92.0 | 97.8 | 97.7 | 81.4 |
| 13 | boiled well-done | 97.9 | 95.6 | 98.3 | 98.8 | 89.8 |
| | Average | 97.1 | 93.8 | 98.1 | 98.3 | 85.6 |
| 14 | Mixed diet; beef | 98.4 | 96.2 | 99.1 | 98.9 | 92.5 |
| 15 | fried | 98.6 | 97.0 | 99.1 | 99.1 | 93.5 |
| | Average | 98.5 | 96.6 | 99.1 | 99.0 | 93.0 |
| 16 | Mixed diet; beef | 97.7 | 94.6 | 98.5 | 98.5 | 86.4 |
| 17 | boiled rare | 98.7 | 96.9 | 99.0 | 99.5 | 92.9 |
| | Average | 98.2 | 95.8 | 98.8 | 99.0 | 89.7 |
| 18 | Mixed diet; beef | 97.5 | 93.3 | 98.0 | 98.8 | 87.3 |
| 19 | broiled | 97.7 | 94.0 | 98.3 | 98.9 | 89.1 |
| | Average | 97.6 | 93.7 | 98.2 | 98.9 | 88.2 |
| | Average of 4 Exp'ts at U. of I. 1899 by Dr. H. S. Grindley on mixed diet. | 97.1 | 94.3 | 97.9 | 97.7 | 84.6 |
| (30) | Average of 6 exp'ts by Dr. Atwater in 1896 on mixed diet | | 93.2 | 96.7 | 98.4 | |
| (31) | Average of 11 exp'ts by Prof. Wait at Uni. of Tenn. in 1896 - 7, on mixed diet. | 95.7 | 92.6 | 94.4 | 97.1 | 63.0 |

## Discussion of Results of Digestion Experiments.

The results of the above digestion experiments seem to indicate that beef round, eaten in a mixed diet, is more completely digested when fried, (without the addition of fat), than when cooked by any of the other methods tried. The duplicate experiments agree well in the case of Exp'ts 14 - 15, and 18 - 19, but do not agree closely in the others. The results of Exp'ts 12 and 13 may not be considered reliable, as a good separation of faeces was not obtained. In the other experiments however good separations were made.

The results of this series of experiments agree well with those of Dr. Grindley obtained in July and August 1899, but are higher than those of Atwater and Wait.

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Arthur W. Palmer

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